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ABSTRACT

By showing how the addition of three universities to the State University System of Florida affected enrollment projections for the six older universities, a tool was developed that may be of use for enrollment projections in other settings, when the system changes. County population and K-12 school enrollment project reasonably well the undergraduate enrollment of students from those counties not strongly influenced by the new universities, at those universities that are not expanding by virtue of new program addition themselves. Treatment of enrollment from counties influenced by the opening of new universities includes the assumption of "constant relative probability." The projection incorporates the probabilities for attending the new university and for attending the given university before the new one opened. Under sufficiently controlled conditions, the projections give reasonable agreement with observed enrollment changes. (Author/JMD)

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Enrollment Projections When the System Changes

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In validating the enrollment projection procedures for Florida's public university system, we have assumed that we made projections of enrollment beginning in 1967 for the six universities which existed then. The complicating element is that three universities were added to the State University System after 1967. That addition affects the projection of the original six, and an investigation of the effect leads to a process for making projections when new programs are initiated or programs are eliminated.

County population and K-12 school enrollment project reasonably well the undergraduate enrollment of students from those counties not strongly influenced by the new universities, at those universities which are not expanding by virtue of new program addition themselves. Treatment of enrollment from counties influenced by the opening of new universities includes the assumption of "constant relative probability." The projection incorporates the probabilities for attending the new university and for attending the given university before the new one opened. Under sufficiently controlled conditions, the projections give reasonable agreement with observed enrollment changes.

Introduction

The projection of enrollments is an important task in each educational setting. Always a challenge, the job becomes especially tricky when the characteristics of the setting change. In a system of universities, a new campus may be opened or one may be closed. At a single university new programs may be initiated or previous programs terminated, and educators talk about new markets and new clienteles. The system for which enrollment is projected consists of a number of interacting parts, which may be universities in a state, colleges in a university, or programs in a college. In the process of changing the system, the critical question which is raised by anyone doing enrollment projections is, how will the changes affect students who do not go to the new institutions or enter the new programs? In answering the question, it helps to have some quantitative aids in order to assist intuition.

This paper will deal with the State University System of Florida, in which there are nine public universities currently. By showing how the opening of universities affected other, older universities of the Florida System, we have developed a tool which may be of use in other settings, when the system changes.

The enrollment projections are all based on the concept of a pool. That is, we attempt to identify groups of similar individuals, or pools, for which we can derive the probability of attending a given university. Projections of enrollment then follow from projections of the size of the pool and the magnitude of the probability for attendance. Before discussing the enrollment projections when the system does change, we will present the results of attempts at validating the methodology which

ignore the changes in the system. Given a number of pools, the probability of attendance from each of these pools is assumed to be constant over time, so that changes in attendance follow changes in the size of the pools. The probability is often termed the participation rate (e.g., Newton, 1976), and with these simplifications the method reduces to a ratio method (e.g, Wing, 1974). Thinking of the behavior as a probability makes the model seem more causal than the phrase, ratio method, implies. In our projections, we do not attempt to predict the changes in probability due to e.g., economic conditions since we believe that the projection of those conditions raise more uncertainties. The question to be raised by the validation process is then, to what extent can the changes in probability of attendance be ignored?

After we have dealt with this question, we will go on to develop a method for treating one kind of change in probability, namely, that created by a change in the number of options which individuals have. Specifically, we will look at the change in probability caused by the opening of a new university. Finally, we will suggest other applications for the method.

Validation of Enrollment Projection Methodology

This paper supposes that in 1967, 1969, or 1971 we had used the present method to obtain projections of undergraduate headcount for the universities of Florida. From those base years, we projected the headcount enrollment of undergraduates who were Florida residents in the years 1975 and 1977. The restriction to Florida residents comes from the methodology which will be explained. The restriction makes little

difference in the overall effort inasmuch as the percentage of out-of-state students within the Florida universities has remained relatively constant over the years at less than 10%. We were required to aggregate all undergraduates because the data available before 1972 combined the four years. This does create a significant problem due to the existence in Florida of upper division universities, which do not enroll students for the freshman or sophomore years.

In addition, there is some lack in comparability of the enrollments before and after 1972 due to a change in definition for which we were not able to correct. There are other questions concerning the treatments of specific items in the history. So there is some fuzziness in the numbers to be used in the validation. We expect that the uncertainties created by the changes in definition between the base years and the "projected" years of 1975 and 1977 are no more than $\pm$ 5% of the enrollments.

For undergraduate projections by university, we employ two pools for each of the counties of Florida. The first pool is the accumulation of students who were in the twelfth grade of the public schools a suitable period before the calculated year in order to allow them to be university students by progressing in lock step from the high school into the university. For example, the pool for university seniors in a given year would include the twelfth grade students four years earlier. The number of students in that group constitute the so called normal pool. At the same time that students enroll in the universities from the normal pool, there are other individuals who come from the population as a whole. Projections of the state population by age group are even more difficult

in an in-migration state as Florida than the projections of total population, and we have chosen to use the total population, including all age groups, as a second pool, out of which students enroll in the universities. Use of the total instead of any age group is equivalent to assuming proportionality between that group and the total. (To avoid the conceptual problem of overlapping pools, one could define the second pool to include all citizens without the normal pool, but that definition would differ from the simpler one by less than 2%. So less than 2% of any shift in the normal pool's proportion is passed on to the total population pool.)

The projection of enrollment for a given university begins by the enumeration of students "currently" enrolled (in the base year) by county. For each of the two pools, we assume that a fraction of the identified students are within the pool, and the growth in size of the pool is projected. The number of students projected to come from that county from that pool is the number in the base year increased by the proportional growth in the pool. This may be shown in Eq. (1).

$$\text{Enrollment (projected)} = \frac{\text{Pool (projected)}}{\text{Pool (base)}} \text{ Enrollment (base)} \qquad (1)$$

The counties are then totaled to get the total enrollment by pool for the university. The two pools are finally combined for the overall projection, E_p. For a given university let f = fraction of base year enrollment from the normal pool (which is not directly known), g = fraction of E_p from the normal pool (which is known), E(g) = projected enrollment assuming the growth comes only from growth in the normal pool, and E(1-g) = projected enrollment assuming the growth comes only from growth

in the other pool. Then the projected enrollment must be

$$E_p = fE(g) + (1-f)\,E(1-g). \qquad (2)$$

The unknown f can be eliminated and the final solution for E_p can be written

$$\frac{1}{E_p} = \frac{g}{E(g)} + \frac{(1-g)}{E(1-g)}. \qquad (3)$$

We assume that the populations and twelfth grade enrollments are known. In fact, population projections would be the limiting factor in our projections of university enrollment, but we are separating that uncertainty from the enrollment projection methodology itself. Recently the state population has actually been about 16% higher than the projection for the same year made eight years before.

The results of our projecting enrollment eight years away, assuming that the base year is 1969, are shown in Table 1. It may be mentioned that, in Florida, 1976 was a year when enrollment decreased compared to 1975 despite an increase in pool sizes, and that 1977 was a recovery year in enrollment. The result of the validation can be shown for each of the four projections as in Table 2. It can be seen that there have been some high years and low years in the history of the State University System. Actual enrollments in the total system, defined as the original universities, range from 109.5% to 95.0% of the projections. A criterion suggested by Folger (1974) is that enrollment projections not deviate from actual enrollments by more than 2% per year. System wide, the projections of Table 2 deviate by about 1% per year or less. With the advantage of hind sight, we could attempt to explain the differences between the

projected enrollments and the actual ones, but that would not be consistent with the desire to validate the enrollment projection methodology.

The exception to explaining deviations between the projections and actual enrollments is to note that other universities entered the State University System during the period of time which spanned the projections. In the 1960's three universities began enrolling students: Florida Atlantic University (FAU), University of West Florida (UWF), and Florida Technological University (FTU). Perhaps the largest deflection of enrollment occurred upon the opening of Florida International University (FIU) in Dade County in 1972, about 40 miles from FAU. That opening offers an easy explanation for the enrollment actually observed at FAU to be generally lower than that projected. The magnitude of the effect can be dramatized by looking at projections of university enrollment from students residing in Dade County. Making projections from 1969 for 1977, we would expect to find 8,314 students at the six universities in the projection. The actual enrollment at those six universities was 6,646. However, the actual enrollment in 1977 at all nine universities from Dade residents was 12,263, with FIU accounting for 5,563 of those students. In short, when a university opens it has a large effect on the enrollments of other universities.

Changes in Probability Due to Changes in the System

The probability of attendance at a given university from a given pool changes when new options are opened to individuals in that pool. In order to treat this change quantitatively we introduce the notion of constant relative probability (Montgomery, 1976). Mathematically,

let p_i be the probability of some alternative labeled i for a given pool, and let p_i' be the probability of the same alternative after a new option exists. Then for any alternatives i and j,

$$p_i/p_j = p_i'/p_j'. \tag{4}$$

If the new alternative is labeled zero, i.e.,

$$p_0 = 0$$
$$p_0' \neq 0 \tag{5}$$

then some algebra leads to the expression

$$p_i'/p_i = 1-p_0' \text{ for } i \neq 0. \tag{6}$$

Conveniently enough, if p_i has been defined for a group by the ratio between number of students and the number in the pool, Eq. (6) still applies when p_0' would be different for different parts of the group. That is, p_0' is defined by a ratio for the same group as p_i.

Clearly the probability of attending a university varies from year to year even in the absence of new openings of universities. So the assumption really is that the relative probabilities remain "sufficiently" constant to give useful results. Intuitively one would expect the assumption to apply less well when the variables determining the probability of attendance depend on uniqueness. For example, if some pool of students attends (simply) the nearest university, opening a new university which is located near their residence should shift the enrollment of the entire pool. To the degree that the assumption works, the probability of enrollment must depend on variables not uniquely defining a university, e.g., the distance between student residence and the university.

Before attempting to use the assumption within an application, one can check it directly, on historic data. The assumption of constant relative probability requires that the ratio of attendance from a given pool at a specific university to the attendance from the same pool at a group of universities stays constant, that is, the fraction of all students going to the specific university stays constant. ("All" refers to a constant number of universities, excluding the new one.) For the three settings in which a public university opened in Florida and we have comparable data for a series of years including the opening, we can test the assumption. The largest effect by the new university should be, in each case, on the county hosting the new university. So we have looked at the three counties corresponding to those three universities.

First, we test the assumption that the fraction of all students going to a specific university stays constant in time with Florida State University (FSU) as the specific university (chosen arbitrarily except that it enrolls large numbers of students from each county). For Escambia County, over nine years which encompass the opening of UWF in Escambia, FSU maintains a fraction of .473 of the total (least squares fit) with an r.m.s. deviation of .033. Similarly, across eight years in Palm Beach county (with FAU opening) and Orange county (with FTU opening), FSU holds at .340 $\pm$ .019 and .294 $\pm$ .025, respectively.

For enrollment projections when the system changes, we keep the same two pools used in the foregoing validation. Within the population pool, the probability is dependent upon the age, so for a moment we treat each age as a separate pool. Except for the ages represented

within the "normal" pool the probabilities are very low for attending any university. The numbers of these individuals who become students are significant only because of the large numbers in the pools. According to Eq. (6) since $1-p_0'$ is approximately 1, the probability of any of the other alternatives is unchanged by the initiation of a new alternative. This behavior makes the concept of constant relative probability usable: if the probability of the new alternative is small for a given pool, modification of probabilities from that pool can be ignored.

So our attention is directed to modification of probabilities from the "normal" pool. Of course, probabilities require two numbers: the number of individuals in the pool and the number of those who follow the given alternative. Equation (6) gives a means of determining the number of individuals who pursue a specific option, attending a given university, after a new option appears, attending a new university. If we restrict ourselves to a given county and to a given university, then we can write

$$n = pN\,(1-n_0'/N) \qquad (7)$$

where n is the number of students at the given university, p is the probability of attending that university from the given county which would exist in the absence of the new university (assumed to stay constant), N equals the number in the pool (allowed to vary from year to year), and n_0' equals the number of individuals from the same pool who are attending the new university (expected to vary from year to year).

We will look at the opening of the three universities from which we have consistent data on the years immediately preceding and following the opening. Our approach is to validate Eq. (7). In order to apply Eq.

(7) to the available data, three more assumptions are necessary. First, the total number of students recorded as going from the county away to a university are all from the normal pool and can be used as n. This assumption is not as violent as it might first appear since students from the other, "population" pool tend to go to the local university. Current data show a very small proportion of students leaving the county to be older individuals, e.g., 10.5% of the students leaving Escambia County are 25 or older, and from counties not adjacent to a university about 16% of the students are 25 or older. Second, since we do not have available the history of the students who attend a university according to age grouping, we assume that the students from the normal age pool maintain the same proportion of all students for whom we have records. This means a proportionality between n_0' and a number labeled as m which gives the total student enrollment from the county at the new university. Third, the normal pool is proportional (not necessarily equal) to the sum of the twelfth grade enrollments within that county lagged by the appropriate number of years to make the individuals in the right university class if they were in lock step; let the sum be H. One of the assumptions is picked up in calculation of the probability p. The other two assumptions of proportionality are absorbed in a single constant, c, as we write

$$n = pH\,(1-cm/H). \tag{8}$$

The constant c turns out to be the problem. In order for us to determine c from the history available, we must wait for one year after the new university has opened in order to evaluate it. That is, c is used as an adjustable parameter to explain the other years after the probability of attendance from the county has changed. With all of these assumptions, we have shown the projections and the actual enrollments

in Figures 1, 2, and 3 for the opening of the three universities. Figure 1 shows the opening of FAU and the enrollment from Palm Beach County at the remaining universities. Figure 2 does the same thing for UWF's opening in 1964, with the enrollment from residents of Escambia County, and Figure 3 shows Orange County enrollment during the years around the opening of FTU in 1968. Since UWF and FAU are upper division universities the enrollments studied as those two opened are upper division. (This required another step in order to separate lower division enrollment from the totals recorded.)

Clearly, the assumption of constant probability p does not hold exactly even before a new university opens. Variations in the actual enrollments after a new university opens compared to the projected enrollments are generally not much greater than the variations which occur in the pre-opening years with actual data compared to the assumption of constant probability. However, one or two years misbehave in each series.

Application

Of the numbers needed for the projection, the one which is of a different character is the enrollment at the new university. In projecting the effect of a new university on other universities, we would assume that the enrollment at the new university was planned or controlled. Otherwise, the numbers needed for the projection come from the kind of demographic information available in institutional research or planning offices. The use of this approach for new programs, rather than new universities, directly parallels the above treatment.

It may not be obvious that the same assumption, constant relative probability, can be used to project the effect of closing options rather than opening new ones. If an option labeled by o is eliminated, then the probability of some other alternative p_i is modified. The new probability for the same alternative p_i' is found through use of the following equation

$$p_i'/p_i = \frac{1}{1-p_o} \qquad (9)$$

Here, as before, the difficulty comes in identifying the correct pool, and one year's experience after the actual elimination of the alternative may be necessary in order to find all parameters. We have used Eq. (9) in association with policy limits on first-time-in-college enrollment to infer the weakness of interaction between the admission of such students at Florida's lower-division universities (Montgomery, 1976).

Conclusions

Projection of undergraduate enrollment based upon pools is a satisfactory method over the long run. There will always be uncertainties in enrollment projection (and university operations should be managed to deal with those uncertainties), but projections which assume changes due to changes in pool sizes must give the base line around which the fluctuations occur. The assumption of constant relative probability gives a useful tool when conditions change by the addition or deletion of options for potential students.

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Table 1

Undergraduate Headcount, Florida Residents

1977 Enrollment as Percentage of 1969 Enrollment

	"Projected"	Actual
University of Florida	132.5	138.9
Florida State University	130.2	113.2
Florida A & M University	126.1	149.8
University of South Florida	133.2	142.0
Florida Atlantic University	141.9	134.2
University of West Florida	127.8	139.7

Table 2

Undergraduate Headcount, Florida Residents

Actual as Percentage of "Projected"

	From 1967 to 1975	From 1971 to 1975	From 1969 to 1977	From 1971 to 1977
University of Florida	103.4	94.0	104.8	102.4
Florida State University	100.3	98.0	87.0	94.1
Florida A & M University	123.8	103.9	118.9	110.6
University of South Florida	130.0	92.2	106.7	86.4
Florida Atlantic University	100.0	78.3	94.6	78.1
University of West Florida		120.9	109.4	114.1
Total (of universities entered)	109.5	95.0	101.1	95.3

FIGURE 1

UNDERGRADUATE UPPER LEVEL ENROLLMENT AT UNIVERSITIES OF FLORIDA AND SOUTH FLORIDA, FLORIDA STATE, AND FLORIDA A&M FROM PALM BEACH COUNTY, SITE OF FLORIDA ATLANTIC UNIVERSITY (FAU)

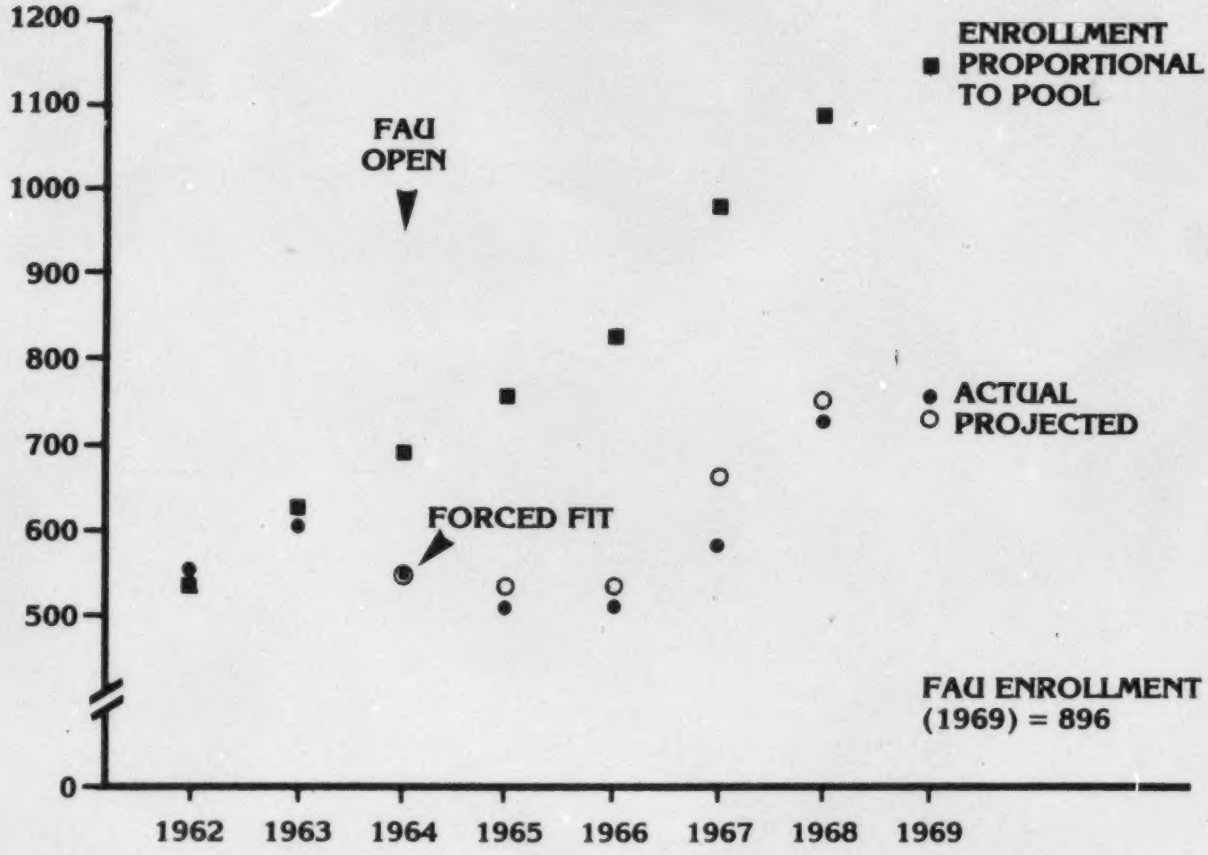

FIGURE 2

UNDERGRADUATE UPPER LEVEL ENROLLMENT AT UNIVERSITY OF FLORIDA, FLORIDA STATE, AND FLORIDA A&M FROM ESCAMBIA COUNTY, SITE OF UNIVERSITY OF WEST FLORIDA (UWF)

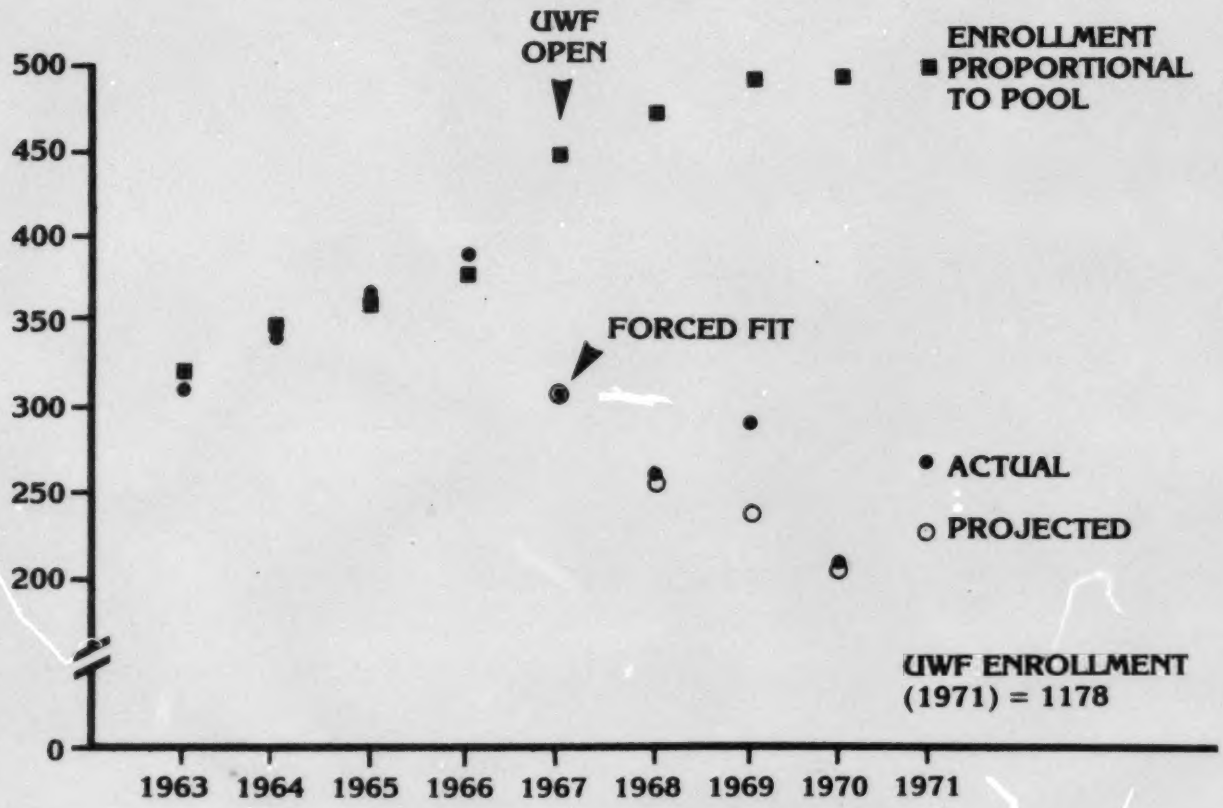

FIGURE 3

UNDERGRADUATE ENROLLMENT AT UNIVERSITIES OF FLORIDA, SOUTH FLORIDA, AND WEST FLORIDA; FLORIDA STATE; AND FLORIDA A&M FROM ORANGE COUNTY, SITE OF FLORIDA TECHNOLOGICAL UNIVERSITY (FTU)